EFFECT OF THE PROCESSING PARAMETERS ON THE PROXIMATE COMPOSITION OF *AKARA* OGBOMOSO

***Adekunle A.A., Oyedele O.J., Jeremiah A.O., Oyekanmi O.F., Onyeka C.F., Akanbi G.A., Adetoro O.B., Adeegbe J.F., Bazambo I.O., Adeyemi A.B., Aremu E.A. and Salaudeen T.F.**

Food processing unit, Bioresources Development Centre, National Biotechnology Development Agency, Ogbomoso, Oyo State, Nigeria

Corresponding Author: adekunleadefemiwa@gmail.com

Abstract
The effect of processing parameters on the proximate composition of *Akara* Ogbomoso was studied. Beans, ginger, pepper, salt and water were the main ingredients used for the preparation of *Akara* Ogbomoso. The regression coefficients (R^2) value for the response equations which is an indication that the processing variables were adequately fitted to the regression equation and could predict the proximate values of the *Akara* Ogbomoso were found to be 0.9922, 0.9488, 0.9670, 0.9932, 0.9494 and 0.9989 for crude protein, crude fibre, crude fat, moisture content, ash content and carbohydrate respectively. The optimum process conditions at a desirability index of 0.932 were X_1 (0.56), X_2 (0.02), X_3 (0.01), X_4 (29.36) and X_5 (171ºC). Processing variables had a significant ($p<0.05$) effect on the proximate composition of *Akara* Ogbomoso. The proximate composition was mostly affected by the cooking temperature

Keywords: beans, pepper, salt, ginger, cooking temperature

Introduction

Cowpea (*Vigna unguiculata*) is an annual legume, commonly referred to as southern pea, black-eyed pea, crowder pea, lubia, niebe, coupe, frijole or china peas (Davis *et al.*, 1991; Patterson, 2002). They are composed of a cotyledon, germ and seed coat with a testa and hilum. The seed coat is where the coloured pigment is contained and it can be removed by decortication to reveal a white seed (Patterson, 2002). Cowpea is a major staple food for many households in developing countries of West Africa. The proximate composition of cowpea has been reported to contain 11% moisture, 24% protein, 1.3% fat, 56.8% carbohydrate, 3.9% fibre, and 3.6% ash and provides 343 Kcal/100g (Deshpande and Damodaran, 1990). The protein in the seed is rich in amino acids, lysine and tryptophan compared to cereal grains (Davis *et al.*, 1991, Ajetunmobi- Adeyeye, *et al.*, 2021).

Paste prepared from cowpea is the basic ingredient in the preparation of many common African dishes, such as moin-moin and *Akara* (Bean cake), prepared by steaming or deep fat frying respectively. *Akara* is the most common cowpea-based derivative known in the South West region of Nigeria. There are two different types of *Akara* depending on the method of preparation/processing, moisture content and the extent of drying. The first type, the conventional *Akara* is the most popular, which is produced by a single deep frying in palm or vegetable oil and contains a lot of moisture which varies considerably between 38.9-49 % (Patterson *et al.*, 2002; Giami *et al.*, 2003). It cannot be stored for more than 8-10 hours at ambient temperature. The second type of *Akara* is dried bean cake (*Akara* Ogbomoso), which is low in moisture content (usually milled as a thick paste without water) and often deep-fried two times in hot vegetable oil, can be stored for 8-10 weeks without spoilage by microorganisms (Adedeji and Ade-Omowaye, 2013)

Akara egbe (Dried bean cake), which is also referred to as *Akara* Ogbomoso, derived its name from its main centre of production, Ogbomoso, an ancient town in Oyo State, Nigeria. It is different from the conventional *Akara* in terms of processing, product characteristics and shelf life (Falade *et al.*, 2003, Ajetunmobi-Adeyeye *et al.*, 2021). The technology involves frying of a low moisture content paste seasoned with salt, in hot vegetable oil to produce a reddish brown, hard textured, low moisture product. *Akara* Ogbomoso is mainly eaten as a snack food, or with water, cereal porridge or soaked garri.

Ajetunmobi-Adeyeye *et al.* (2021) reported the optimum conditions of *Akara* Ogbomoso to be the frying temperature of 190°C, frying time of 8.5 min and 20% Bambara groundnut in the flour blend, having desirability of 0.886 with a moisture content of 4.84%, 9.76% oil content, 343.812 N crispness and 15.433 colours. The quality of *Akara* Ogbomoso varied from one processor to the other due to a lack of standardization of the processing conditions and ingredients formulation. Oyeyinka, *et al.* (2017) reported that *Akara* egbe prepared from Bambara groundnut flour showed significantly ($p \leq 0.05$) higher protein content (23.41%) than the sample made from Bambara groundnut paste (19.35%). *Akara* egbe prepared from cowpea paste had higher ratings in aroma, colour, taste, crunchiness and overall acceptability than those made from cowpea flour or Bambara groundnut paste or flour.

Results of proximate analysis obtained by Ogundele, *et al*, (2014) revealed that the combination of cowpea and soybean blends had a higher protein content (15.20, 18.31and 22.52%) ash content (1.74, 1.80 and 1.88%) crude fat (3.38, 4.06 and 5.28%) and crude fibre (1.03, 1.10 and 1.19%) compare to individual cowpea control (sample A) which have only 4.44% (protein) 1.17% (ash) 1.91% (crude fat) and 0.92% (crude fibre) respectively. Adedeji and Ade-Omowaiye (2013) investigated the effects of *Aframomum danielli* and *Zingiber officinale* crude extract on the storability of fried bean cake snacks. Proximate and sensory analyses of the snack were also assessed. Proximate analyses revealed that moisture content ranged from 0.85-1.05 %, crude protein 80.00-78.70 %, crude fat 2.09-1.08 %, crude ash 1.50-1.30 %, crude fibre 2.00 - 1.80 %, total carbohydrate 10.25 -

12.75 % and dry matter 3.52 - 2.30 %. The sensory evaluation shows that there was no significant difference (p<0.5) between the treated and untreated samples in terms of all the sensory attributes evaluated.

Most published studies on *Akara* Ogbomoso over the years have dealt primarily with final product quality and none of these reports have particularly optimized the effect of processing parameters to obtain fried *Akara* Ogbomoso of acceptable quality attributes. Therefore, the aim of this research work was to optimize the deep fat frying process and ingredients composition for the production of *Akara* Ogbomoso.

Materials and Methods

Preparation of samples

The Black-eyed cowpea (*Vigna unguiculata L*), pepper (*Genus capsicum*), ginger (*Zingiber officinale*), salt and vegetable oil used in this study were purchased from Sabo market in Ogbomoso, Oyo State, Nigeria. The method of Falade *et al*. (2003) was used. The cowpea seeds were hand-picked to remove chaffs, stalks and stones after which it was broken into smaller sizes using a grinding mill. The broken cowpea was then dehulled during the washing process after which it was sun-dried. The dried cowpea was then pulverized using a locally fabricated grinding mill.

Cooking Process

Ginger (1.86 - 3.86 g) and pepper (0.60 - 1.42 g) were mixed in the right proportion with the cowpea (23.08 - 39.02 g) along with salt (0.59 - 0.75 g) and water (57.53 - 72.57 g) to form a paste. The paste was properly mixed and transferred to a piping bag with a nozzle at the tip. The piping bag was handled manually so that the mixture paste entered into the hot vegetable oil taking the shape of the nozzle tip. The paste was then deep fried for 7 minutes at a temperature of 130-189 ºC to produce *Akara* that is not completely cooked. The *Akara* (incompletely cooked) was allowed to cool for 5 minutes and then fried again for another 9 minutes to produce crispy, hard chips with very low moisture content *Akara*. The *Akara* was then drained of oil, cooled and packaged into a low-density polyethylene bag (Falade, *et al*., 2003) at room temperature and kept for analysis.

Proximate analysis

The method of the Association of Official Analytical Chemists (2015) was used to determine the proximate (moisture content, crude protein, crude fibre, total ash, crude fat and total carbohydrate) of *Akara* Ogbomoso.

Experimental Design

The study was based on the functionality of the proximate analysis (moisture content, protein, crude fibre, ash, crude fat and carbohydrate) as it fits into the regression equation. The ingredients listed in descending order of assumed importance to quality variables are shown in Table 1. The *Akara* Ogbomoso composition has the form: A (beans) + B (pepper) + C (salt) + D (water) + E (ginger) = 100%. Singh *et al.,* (2003) explained that this mathematical equation depends linearly on variables on the condition that the amounts of ingredients are used directly as variables. Making the equation function in a multiple factor analysis, the ingredients could be represented in ratio form which in turn makes it to be varied independently. The ingredients ratios as x_i variable are:

$$x_1 = \frac{A}{B+C+D+E} = 0.471$$

$$x_2 = \frac{B}{C+D+E} = 0.015$$

$$x_3 = \frac{C}{D+E} = 0.008$$

$$x_4 = \frac{D}{E} = 0.039$$

To get at least satisfactory results, a centre point for the design was selected with the various ingredients. With the centre composition selected, the normal x_i ratios were calculated by using the normal weight composition of the formulation given in Table 1.

Table 1: Formula composition at the centre point of the design

Ingredients (%)	Total mixture basis	Weight (g)
A. Beans	32	320
B. Pepper	1	10
C. Salt	0.5	5
D. Ginger	2.5	25
E. Water	64	640
Total	100	1000

The increments of variation for each variable spaced around the centre point ratios, along with the equations relating the actual and coded ratios, are presented in Table 2. The experimental design shows the value of the coded x_i ratios translated into working quantities for each of the ingredients thereby leading to a systematic algebraic solution for A, B, C and D in terms of actual x_i ratios and a unit quantity of product. Equations derived for the general case follow:

$$A = \frac{100x_1}{x_1+1}$$

$$B = \frac{100x_2}{(x_1+1)(x_2+1)}$$

$$C = \frac{100x_3}{(x_1+1)(x_2+1)(x_3+1)}$$

$$D = \frac{100}{(x_1+1)(x_2+1)(x_3+1)}$$

Table 2: Experimental increments, values of coded levels and equations relating actual x_i and coded X_i ratios

x_i Variables	$\pm$ Increment	X_i coded levels -1	0	+1
x_1	0.2	0.377	0.471	0.565
x_2	0.15	0.013	0.015	0.017
x_3	0.15	0.007	0.008	0.009
x_4	0.2	0.031	0.039	0.047
x_5 (Temp)	0.25	144	160	189

Table 3: Central composite design arrangement

	Treatment level Composition				
Expt. No	X_1	X_2	X_3	X_4	X_5
1	0.38	0.02	0.01	0.03	144.00
2	0.30	0.01	0.01	0.04	160.00
3	0.56	0.02	0.01	0.05	144.00
4	0.47	0.01	0.01	0.04	160.00
5	0.47	0.01	0.01	0.02	160.00
6	0.38	0.02	0.01	0.05	176.00
7	0.56	0.02	0.01	0.03	144.00
8	0.47	0.01	0.01	0.04	160.00
9	0.64	0.01	0.01	0.04	160.00
10	0.56	0.01	0.01	0.03	176.00
11	0.47	0.01	0.01	0.04	160.00
12	0.38	0.01	0.01	0.05	176.00
13	0.47	0.01	0.01	0.04	130.86
14	0.47	0.01	0.01	0.04	160.00
15	0.56	0.01	0.01	0.05	144.00
16	0.56	0.01	0.01	0.05	176.00
17	0.47	0.01	0.01	0.05	160.00
18	0.56	0.02	0.01	0.03	176.00
19	0.47	0.02	0.01	0.04	160.00
20	0.38	0.02	0.01	0.05	176.00
21	0.38	0.01	0.01	0.03	144.00
22	0.47	0.01	0.01	0.04	189.14

X_1- bean ratio, X_2- pepper ratio, X_3- salt ratio, X_4- ginger ratio, X_5- cooking temperature

Table 3 shows the actual weights for each ingredient in different treatments. The Response Surface Methodology (RSM) experimental design was based on a rotatable, central composite, response-surface model with five factors and three levels using design expert software 6.0.8 according to Cocharan and Cox (1957).

Analysis of Data

Multiple regression analysis was used to fit the model, represented by an equation, to the experimental data. Mathematical optimiser procedure which deals with constraints was used in performing the maximization and minimisation of the polynomial. The constraints were set to get coded values of a variable between the lower and upper limits (-1 and +1) for an optimum response (a minimum and a maximum) level was provided for each parameter included. A weight was assigned to each goal to adjust the shape of its particular desirability function. The goals were; combined into an overall desirability function. The goals were; combined into an overall desirability function. The program seeks to maximize this function Cthocharan and Cox (1957).

Results and Discussion

The proximate composition of the Akara Ogbomoso is shown in Table 4. The crude protein, crude fibre, carbohydrate, moisture content, ash content and crude fat ranged between 15.75 - 27.13 %, 0.10 - 2.03 %, 34.00 - 50.00 %, 2.00 - 4.02 %, 2.00 - 6.00 % and 20.54 - 41.72 % respectively.

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The regression coefficients significant at 95% and 99% based on t-statistics were selected for developing the following models:

Crude Protein, (M_1) = $-83.49- 293.32X_1+642.20X_2 + 28874.64X_3 - 0.18X_4+ 0.713X_5 + 10979.21X_1X_2 +1.78X_1X_4 + 0.58X_1X_5- 7.32E+05X_2X_3-111.42X_3X_5-4.26E-3X_4X_5$

Crude Fibre, (M_2) = $174.35-55.11X_1-6308.88X_2-11467.63X_3 +2.03X_4-1.19X_5 + 2268.47X_1X_2 +9.19X_1X_3-1.09X_1X_4 + 0.34X_1X_5+ 2.33X_2X_3-50.59X_2X_4+ 30.84X_2X_5 -93.49X_3X_4 + 34.76X_3X_5 + 5.80E-04X_4X_5$

Crude Fat,(M_3) = $160.07-604.05X_1 - 20500.49X_2+66735.45X_3+ 5.94X_4 - 2.06X_5 + 5422.48X_1X_2-23819.87X_1X_3 + 1.90X_1X_4+3.97X_1X_5-2.19E-05X_2X_3+118.86X_2X_4+ 102.39X_2X_5 - 983.67X_3X_4 - 155.29X_3X_5 - 4.02E-03X_4X_5$

Moisture Content, (M_4) = $-18.48+9.96X_1 + 233.69X_2+13532.34X_3-1.52X_4- 0.24X_5- 1089.06X_1X_2-5098.87X_1X_3 + 0.60X_1X_4 + 0.20X_1X_5-2.41E+05X_2X_3+28.61X_2X_4+9.23X_2X_5- 94.54X_3X_4-30.11X_3X_5+9.74E-03X_4X_5$

Table 4: Experimental design and responses

	Treatment Level Composition					Responses					
Expt.No	X_1	X_2	X_3	X_4	X_5	Crude Protein	Crude Fibre	Carbohydrate	Moisture Content	Ash Content	Crude Fat
1	0.38	0.02	0.01	0.03	144	19.25	0.10	50.00	2.01	2.01	26.63
2	0.3	0.01	0.01	0.04	160	19.26	0.12	48.02	2.00	4.01	26.61
3	0.56	0.02	0.01	0.05	144	21.88	2.03	36.00	2.03	4.02	34.04
4	0.47	0.01	0.01	0.04	160	21.01	2.00	46.00	2.00	4.02	24.97
5	0.47	0.01	0.01	0.02	160	21.02	0.11	44.00	2.00	2.02	30.85
6	0.38	0.02	0.01	0.05	176	15.75	2.00	48.00	2.01	2.03	30.21
7	0.56	0.02	0.01	0.03	144	23.63	2.02	38.00	2.00	6.00	28.35
8	0.47	0.01	0.01	0.04	160	20.13	0.13	36.00	2.02	4.00	37.72
9	0.64	0.01	0.01	0.04	160	21.02	2.01	38.01	2.00	2.03	34.93
10	0.56	0.01	0.01	0.03	176	19.25	0.13	46.00	2.02	2.02	30.58
11	0.47	0.01	0.01	0.04	160	21.00	2.00	38.00	2.00	6.00	31.00
12	0.38	0.01	0.01	0.05	176	20.13	0.12	34.00	2.01	2.02	41.72
13	0.47	0.01	0.01	0.04	130.86	21.00	2.00	48.01	2.02	2.02	24.95
14	0.47	0.01	0.01	0.04	160	21.00	0.12	44.02	3.03	4.04	27.79
15	0.56	0.01	0.01	0.05	144	22.75	0.10	36.00	2.00	4.03	35.12
16	0.56	0.01	0.01	0.05	176	21.02	0.10	50.00	4.01	4.02	20.85
17	0.47	0.01	0.01	0.05	160	21.88	0.13	44.00	2.01	4.00	27.98
18	0.56	0.02	0.01	0.03	176	27.13	2.01	46.03	2.02	2.00	20.54
19	0.47	0.02	0.01	0.04	160	20.13	2.01	42.00	2.01	4.01	29.84
20	0.38	0.02	0.01	0.05	176	19.25	0.14	46.01	4.02	2.00	28.58
21	0.38	0.01	0.01	0.03	144	21.01	2.02	46.01	2.00	2.01	26.95
22	0.47	0.01	0.01	0.04	189.14	19.25	0.11	48.00	2.02	2.00	28.62

Ash Content, $(M_5) = -145.75-241.40X_1+9636.57X_2 + 12376.02X_3-0.07X_4+1.05X_5+ 3654.41X_1X_2+ 7818.11X_1X_3+3.61X_1X_4 + 0.16X_1X_5-4.29E+05X_2X_3 - 35.60X_2X_4- 42.14X_2X_5 - 61.86X_3X_4 - 50.20X_3X_5 - 3.73E-03X_4X_5$

Carbohydrate, $(M_6) = 22.81+1137.48X_1 + 17875.53X_2- 1.18E+05X_3-6.26X_4 + 2.01X_5-21291.31X_1X_2 + 28177.89X_1X_3- 6.45X_1X_4-5.34X_1X_5+1.50E+06X_2X_3- 71.74X_2X_4-113.32X_2X_5 + 1307.01X_3X_4+288.62X_3X_5 - 1.49E-03X_4X_5$

Effect of process parameters on the crude protein of Akara Ogbomoso

Proteins are highly complex organic compounds made up of a sequence of amino acids. The protein content value of *Akara* Ogbomoso ranged between 15.75 and 27.13 %. The regression model equation shows that the beans ratio (X_1) and ginger ratio (X_4) are negative while the pepper ratio (X_2), salt ratio (X_3) and cooking temperature (X_5) are positive. The regression equation infers that there may be an increase in the protein content as the pepper ratio, salt ratio and cooking temperature increase while the negative sign may be an indication of a reduction in the protein content as the beans ratio and ginger ratio increase. The decrease in the protein content as the beans ratio increases as shown in Figure 1 could be attributed to the denaturation of protein due to the high thermal energy to which the food materials were subjected too during cooking (Omohinmi *et al*., 2013). The R^2 value from the model equation was found to be 99.2% which shows that the regression model was very suitable for describing the protein content of the sample under cooking variables.

Effect of process parameters on the crude fibre of Akara Ogbomoso

High intake of crude fibre which prevents diet-related diseases has been reported by some researchers. These diseases are cardiovascular disease, cancer of the colon and diabetes (Schulze *et al*., 2004). Odour *et al*. (2008) stated that crude fibre plays a major role in the repairs of peristaltic movement of the intestinal tract thereby preventing constipation. The crude fibre for the *Akara* Ogbomoso was found to range from 0.1 to 2.03%. The response surface plot for crude fibre as a function of beans ratio and cooking temperature is shown in Figure 2.

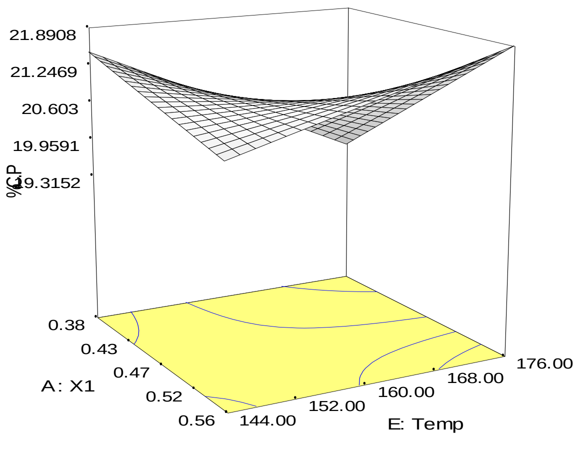

Figure 1: Response surface plot for crude protein content as a function of beans ratio and cooking temperature

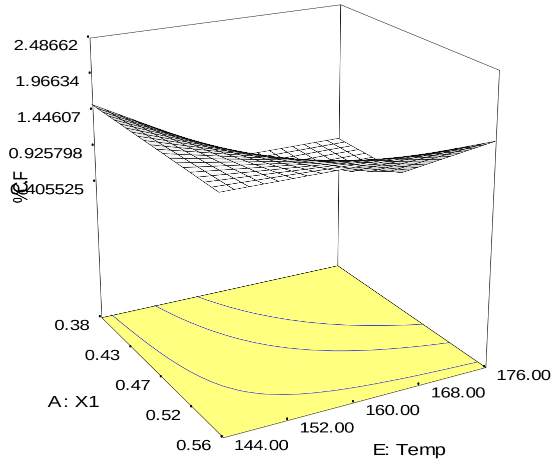

Figure 2: Response surface plot for crude fibre as a function of beans ratio and cooking temperature

The model equation coefficients of beans ratio (X_1), pepper ratio (X_2), salt ratio (X_3) and cooking temperature (X_5) were found to be negative while the ginger ratio (X_4) is positive. This suggests that as the beans ratio, pepper ratio, salt ratio and cooking temperature increase, the crude fibre of the *Akara* Ogbomoso decreases while the increase in the ginger ratio may lead to an increase in the crude fibre of the products. According to Omodara and Aderibigbe (2014), this change (increase or decrease) in the crude fibre could be attributed to the cleavage of carbohydrate leakages which in turn shift form from an insoluble state to a soluble state. The regression model developed to predict the content of the crude fibre explained 94.9% of the variations.

Effect of process parameters on the crude fat of Akara Ogbomoso

The crude fat found in the *Akara* Ogbomoso ranged between 20.54 and 41.72 %. The R^2 value for the crude fat (96.7%) was high as shown in Table 5. This explained a high proportion of the model variables. Figure 3 shows the response surface plot for crude fat as a function of beans ratio and cooking temperature. The regression equation shows that the coefficients of beans ratio (X_1), pepper ratio (X_2) and cooking temperature (X_5) are negative, while salt ratio (X_3) and ginger ratio (X_4) are positive. An increase in the salt ratio and ginger ratio may likely increase the crude fat in the *Akara* Ogbomoso, whereas an increase in the beans ratio, pepper ratio and cooking temperature may decrease the crude fat of the food sample. Oil intake, especially saturated fat, is recognized as one of the major factors responsible for health challenges such as obesity and coronary heart disease (Saguy and Dana, 2002; Mellema, 2003). During frying, the moisture content in the food product evaporates and is replaced by oil. This in turn increased the foaming capacity of the paste thereby, allowing more air to be incorporated into the paste which may eventually result in high moisture loss.

Effect of process parameters on the moisture content of Akara Ogbomoso

The moisture content of food materials during production and packaging processes has been known to be crucial in ensuring the quality and safety of the product. The moisture content of *Akara* Ogbomoso as observed in this study ranged between 2 and 4.02%. It has been established that as moisture content is lowered in a food material, microbial activities are lowered thus, resulting in a higher storage period of the food products (Olitino *et al.*, 2007; Ogunmodimu *et al.*, 2015).

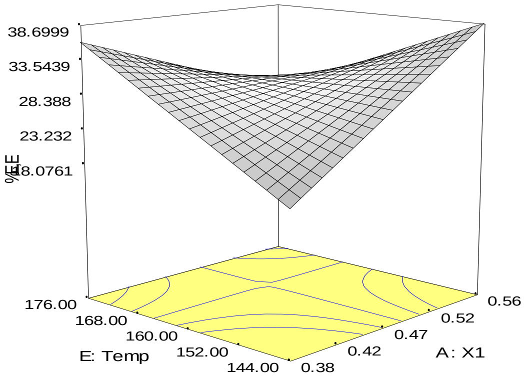

Figure 3: Response surface plot for crude fat as a function of beans ratio and cooking temperature

The values of the moisture content reported for *Akara* Ogbomoso are within the range (0 - 15 %) that prevents activities of microorganisms which promote spoilage, and ensure shelf stability of the foods. The response surface plot for moisture content as a function of beans ratio and cooking temperature is shown in Figure 4. The regression equation shows the linear and interaction coefficients of *Akara* Ogbomoso as it affects moisture content. The equation revealed that the beans ratio(X_1), pepper ratio (X_2) and salt ratio (X_3) are positive. This suggests that there may be an increase in the moisture content of *Akara* Ogbomoso as the beans ratio, pepper ratio and salt ratio increase. An increase in the protein content of a paste may lead to an increase in the absorption of moisture. This increase in water absorption may be attributed to the availability of less moisture which may result in bubble formation, hence, making a foam which invariably increases the moisture content of the paste.

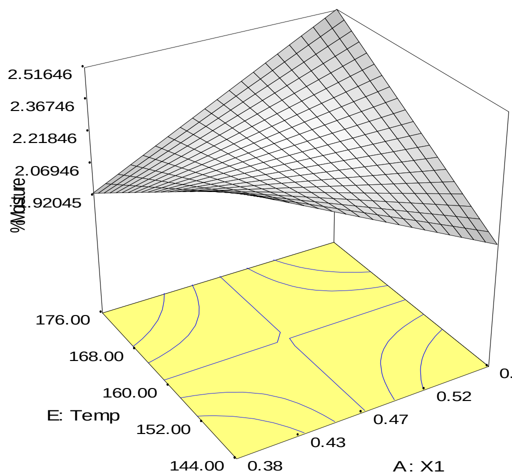

Figure 4: Response surface plot for moisture content as a function of beans ratio and cooking temperature

Ginger ratio (X_4) and cooking temperature (X_5) on the other hand, were found to have negative coefficients, an indication that moisture content decreases as ginger ratio and cooking temperature increase. The regression model predicts that moisture content could explain 99.3% of the variation.

Effect of process parameters on total ash content of Akara Ogbomoso

The total ash content of a sample is a measure of the amount of inorganic non-combustible material it contains. The total ash content observed for *Akara* Ogbomoso ranged between 2 and 6%. Figure 5 shows the response surface plot of the total ash content as a function of beans ratio and cooking temperature. The regression equation of the total ash content revealed the coefficients of beans ratio (X_1) and ginger ratio (X_4) to be negative. The implication of the negative sign indicates that the total ash content of the *Akara* Ogbomoso decreases as the beans ratio and the ginger ratio increase. The decrease in the total ash may be attributed to possible losses of the dry matter and volatile compounds which normally occur during processing. An increase in pepper ratio (X_2), salt ratio (X_3) and cooking temperature (X_5) was observed from the regression equation to increase the percentage of ash content in the *Akara* Ogbomoso. The R^2 value of 94.9% observed for the ash content of *Akara* Ogbomoso indicated that the regression model was appropriate for describing the variables on the ash content of *Akara* Ogbomoso.

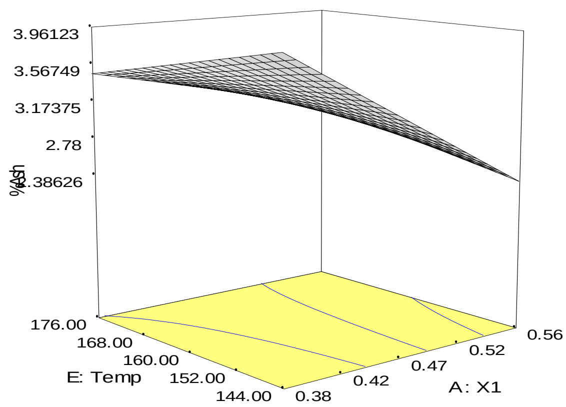

Figure 5: Response surface plot for total ash content as a function of beans ratio and cooking temperature

Effect of process parameters on carbohydrates content of Akara Ogbomoso

Carbohydrates, which range from simple sugars to complex molecules, are essential sources of energy for the body. Results observed from the cooking of *Akara* Ogbomoso ranged between 34 and 50%. Equation from the regression model shows that the beans ratio (X_1), pepper ratio (X_2) and the cooking temperature (X_5) are positive. This is an indication that the carbohydrate content of *Akara* Ogbomoso may increase as the bean ratio, pepper ratio and cooking temperature increase. Salt ratio (X_3) and ginger ratio (X_4) revealed a negative sign, an indication that carbohydrate content may reduce with an increase in salt and ginger ratios. The regression model was found to be suitable for describing the carbohydrate content with an R^2 value of 99.9%. Figure 6 shows the response surface plot for the carbohydrate content as a function of beans ratio and cooking temperature. The increasing trend in the carbohydrate content as cooking temperature increases could be ascribed to intense mechanical

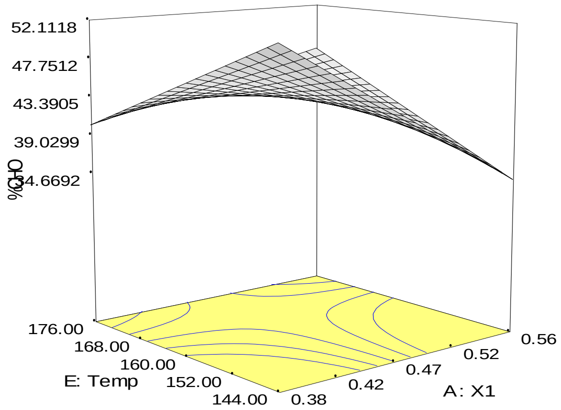

Figure 6: Response surface plot for carbohydrate content as a function of beans ratio and cooking temperature shearing which can bring mechanical breakage of bonds that are capable of holding some carbohydrate contents during the process of cooking. A report from Samaila and Nwabueze, (2013) on quality evaluation of a full-fat blend of African breadfruit-soybean-corn snacks agreed with the increasing trend.

Conditions for Optimum Responses

The models (M_1, M_2, M_3, M_4, M_5 and M_6) were appropriate for demonstrating the path in which variables change in order to maximize protein content, minimize crude fat and make other responses in range. The multiple regression equations were solved for the maximum protein content (25.63%) and minimum crude fat (12.56%). The optimum cooking conditions were (beans to pepper-salt-ginger-water ratio, X_1 = 0.56), (pepper to salt-ginger-water ratio, X_2 = 0.02), (salt to ginger-water X_3 = 0.01), (ginger to water ratio, X_4 = 29.36) and (cooking temperature, X_5 = 171°C) while the optimum values were protein content = 25.63, crude fibre = 1.99, Crude fat =12.56, Moisture content = 3.86, Ash content = 5.06 and carbohydrate = 49.99, at a desirability constraint of 0.932.

Conclusion

Processing variables (cooking temperature and ingredients ratios) have significantly affected the proximate composition of *Akara* Ogbomoso. The proximate properties were mostly affected by cooking temperature. The optimization results based on the desirability concept of the *Akara* showed that the cooking temperature (171 °C), with feed formulation ratio of beans to pepper-salt-ginger-water ratio, 0.56, pepper to salt-ginger-water ratio, 0.02, salt to ginger-water,0.01, ginger to water ratio, 29.36 would produce *Akara* Ogbomoso of better proximate composition.

Declaration of interest

The authors have no relevant financial or non-financial interests to disclose.

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